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PROTECTIVE CIRCUIT FOR PULSED MICROWAVE GENERATOR

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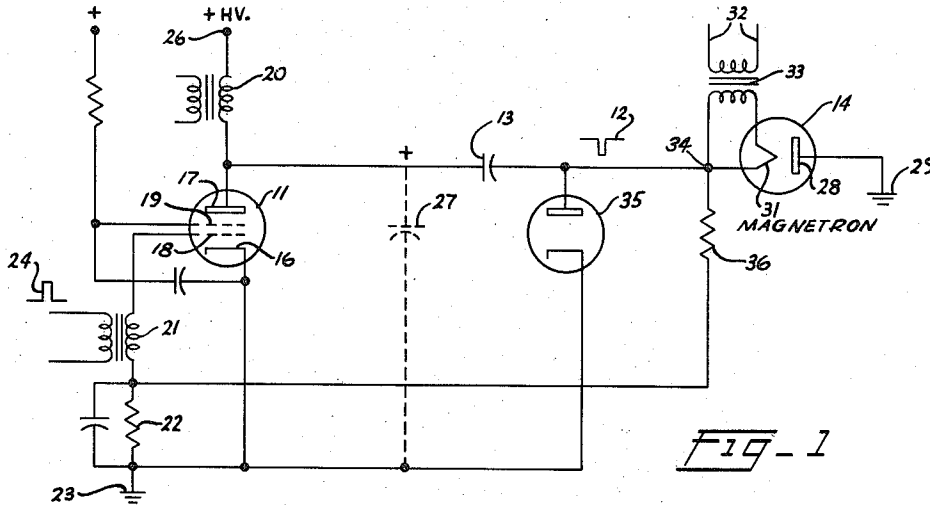


Fig-1

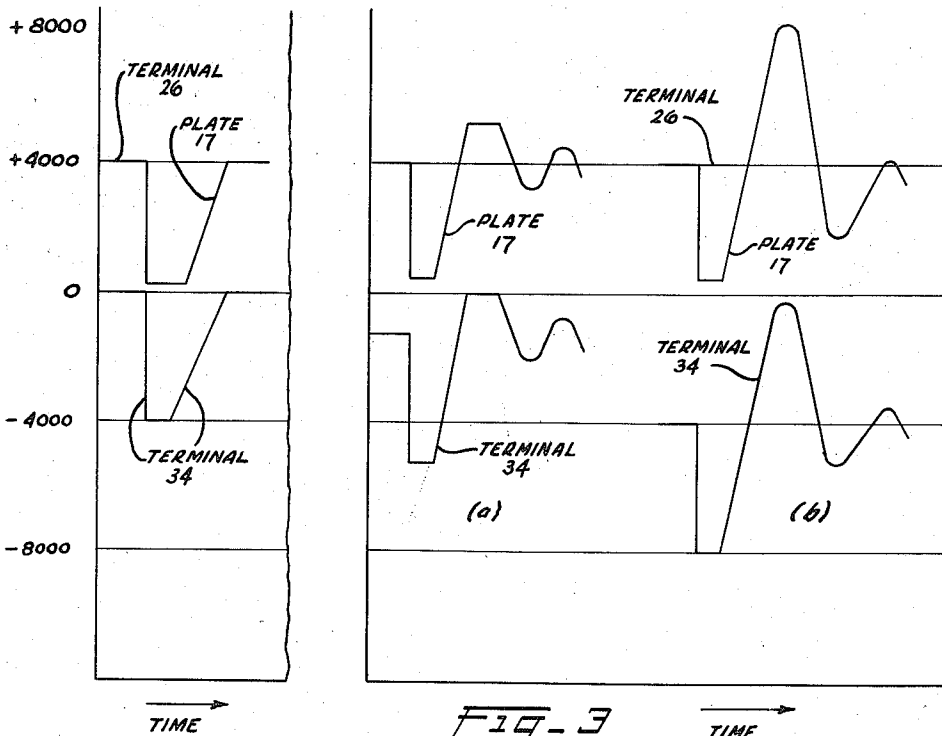


Fig-3

Fig-2

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PROTECTIVE CIRCUIT FOR PULSED MICROWAVE GENERATOR

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3 Claims. (Cl. 332—5)

This invention relates to a protective circuit for preventing excessive voltage in the pulser in a pulsed microwave generating system in the event of sudden impedance changes in the generator due to failure of the magnetron to load the pulser for any reason. Since a magnetron is the most common form of pulsed microwave generator the invention will be illustrated in connection with this specific type of generator but without limitation thereto.

In pulsed radio echo devices where magnetrons are commonly used it is generally the practice to pulse-modulate the operation of the magnetron. The usual way to pulse-modulate a magnetron is to sharply vary the voltage applied between its anode and cathode from below cut-off to normal operating voltage. One of the usual ways of doing this is to use a power amplifier modulator system, commonly called a "pulser," capable of supplying narrow high voltage pulses to the magnetron.

The pulser system includes a high impedance in the anode circuit of the modulator tube. This impedance consisting of an inductance and its inherent stray capacity constitute a resonant circuit which is shocked into oscillation by the triggering pulses applied to the power amplifier modulator tube. These oscillations are damped by the magnetron load under normal operating conditions. When the magnetron load decreases for any reason, such as in the event the heater burns out the damping action of the magnetron is decreased. Then as the coupling condenser charge builds up the damping action diminishes sharply and extremely high potentials develop which may damage the equipment. As long as the magnetron is functioning properly it loads the modulator so that the voltage pulses do not become dangerously high.

The primary object of this invention is to provide a protective circuit which will automatically prevent excessive voltages in the event of failure of the normal operation of the magnetron.

Other objects will become apparent from the following description when considered in connection with the accompanying drawing in which:

Figure 1 is a circuit diagram illustrating the invention;

Figure 2 is a graphical representation of a comparison of the voltages occurring at the points indicated during normal operation; and

Figure 3 is a graphical representation of the comparison of voltages at the points indicated at two successive instants of time when the magnetron fails to load the pulser.

The essential feature of the invention is the provision of an automatic protective bias on the control grid of the pulser tube to prevent dangerously high voltages in its output in the event the magnetron fails to load the output of the pulser.

Referring to the drawing, a screen grid pulser tube 11 is provided for supplying high-voltage pulses 12 through a coupling condenser 13 to a microwave generator, such as a magnetron 14. The modulator tube 11 has a cathode 16, an anode 17, a control grid 18 and a screen grid

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19. The screen grid 19 is connected to a suitable source of direct current potential in a conventional manner. The input circuit of the pulser tube 11 includes the secondary of an input pulse transformer 21 in series with a suitable self-biasing resistor 22 between the control grid 18 and the cathode 16 which is grounded at 23. The input transformer 21 of the pulser tube 11 is adapted to be supplied with trigger pulses 24 from a suitable trigger generator, such as a blocking oscillator or a similar device (not shown).

The anode 17 of the pulser tube 11 is connected to a suitable source of high-voltage direct current represented by the terminal 26 through an isolating inductor 20. The stray capacity between: the inductor 20; the anode 17; the associated circuit elements; and ground is represented at 27.

The magnetron 14, serving as the pulsed microwave generator, is of conventional construction and is provided with an anode 28, grounded at 29, and a cathode 31 energized from a suitable alternating current source through a transformer 33. The negative high voltage pulses from the pulser tube 11 are impressed on the cathode 31 of the magnetron 14 at terminal 34.

A suitable diode 35 is connected between the cathode terminal 34 of the magnetron 14 and ground in order to provide "tail damping" on the output of the pulser. A very high value resistor 36 is also connected between the terminal 34 and the grid end of the bias resistor 22 of the pulser tube 11. The resistor 36 constitutes a sensing device in the output of the pulser tube 11 to limit the maximum value of the output pulses in a manner described below. The parameters of the pulser tube 11, including the bias voltage on the screen grid 19, are so adjusted as to provide the proper voltage pulses at the terminal 34 when the magnetron is operating normally and is thus providing the proper load for the pulser 11.

In operation, during the quiescent state of the pulser tube 11, the control grid 18 is biased to cut-off and the screen grid 19 is held at a normal positive voltage. During this quiescent state the condenser 13 is charged from the high voltage source 26 through the isolation inductor 20 and the diode 35. When a sufficiently large positive pulse is applied through the transformer 21 to the control grid 18, the pulser tube 11 will become conductive. Since the voltage on the condenser 13 cannot change instantaneously, the right hand side will assume a high negative potential which will be applied to the terminal 34 of the magnetron to start it into oscillation. This negative charge on terminal 34 will be maintained during the time of the triggering pulse while the pulser tube 11 is conductive. The capacity of the condenser 13 should be such that its potential does not drop substantially during a pulsing interval, as is well known in the art. As soon as the positive trigger pulse is removed from the grid 18, the tube 11 will become quiescent and the condenser 13 will recharge through the inductor 20 and the diode 35.

If the power supply to the heater 31 of the magnetron should fail, or in the event that the heater 31 should burn out, so that the magnetron does not constitute a load to absorb the output of the pulser, extremely high potentials will develop between the terminal 34 and ground. The diode 35 constitutes a closed switch for pulses positive with respect to ground so that when the condenser 13 is being charged through the inductor 20 during the quiescent condition of the pulser tube 11, the right hand side of condenser 13 (and terminal 34) is at substantially ground potential. Another way of looking at it is to say that the diode 35 constitutes 100% damping for positive pulses.

The inductance of the inductor 20 and its inherent stray capacity indicated at 27 together constitute a

resonant circuit which is shocked into oscillation by the triggered operation of the pulser tube 11. It is normally damped by the load of the magnetron 14 and the diode 35; the diode 35 absorbing all the positive pulses and the magnetron 14 absorbing the energy in the negative-going pulses. The voltage at terminal 34 with respect to ground during normal operation of the magnetron is illustrated in Fig. 2.

If for some reason the magnetron 14 fails to oscillate, or should the heater burn out, the magnetron will no longer act as a load to absorb the energy in the negative-giving pulses. Accordingly, this energy goes into the resonant oscillating circuit, including the stray capacity 27, and as the charge on the coupling condenser begins to build up the difference of potential between terminals 26 and 34 becomes greater and greater on successive cycles (a) and (b) in Fig. 3. If this oscillatory condition is uninhibited destructive potentials will damage or destroy the equipment.

In accordance with the present invention, the sensing resistor 36 between the terminal 34 and the grid end of the self-biasing resistor 22 automatically increases the negative bias on the grid 18 in the event the load between terminal 34 and ground decreases thereby reducing the excursions of the grid 18 to limit the output pulses of tube 11.

What is claimed is:

1. In combination in a circuit for a magnetron having a cathode and an anode, a modulator tube having an anode, cathode and a control grid, an input circuit for said modulator tube including a self-biasing resistor between said control grid and its associated cathode, a source of high voltage direct current for the anode of said modulator tube, a modulation inductor between said source and the anode of said modulator tube, a coupling condenser between the anode of said modulator tube and the cathode of said magnetron; a protective resistor connected between the cathode of said magnetron and the grid end of said biasing resistor for increasing the voltage across said self-biasing resistor toward cut-off to reduce the output voltage pulses from said modulator.

2. In combination a pulsed modulation high frequency generating system comprising, a modulator tube having

an anode, cathode and control grid, an input circuit for said tube including a self-biasing resistor connected between said cathode and said control grid, a source of high voltage for said anode, a modulation inductor connected between said source and said anode to generate high counter voltage pulses in response to pulsed signals applied to said control grid, a high frequency generator adapted to be intermittently operated by the high counter voltage pulses generated by said inductor, a coupling capacitor between the anode side of said inductor and said high frequency generator, and an asymmetrical conducting device between said high frequency generator and ground for shaping the output pulses from said modulator; a protective circuit including a bleeder resistor connected between said high frequency generator and the grid side of said biasing resistor for increasing the voltage across said bias resistor toward cutoff to reduce the output voltage pulses from said modulator.

3. In a pulse modulation system including a pulse modulator space discharge device and a high frequency generator triggered into operation by unidirectional high voltage pulses from said modulator device, said latter device having an anode, a cathode and a control electrode, an input circuit for said modulator including said control electrode and a self-biasing resistor, said high frequency generator having a cathode and an anode, a source of high voltage for the anode of said modulator, a modulation inductor in the anode circuit of said modulator, a coupling circuit between the anode of said modulator and the cathode of said high frequency generator, and means responsive to an increase in voltage in said coupling circuit for increasing the voltage across said self-biasing resistor toward cut-off to reduce the output voltage pulses from said modulator.

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